Electron-capture-delayed Fission Studies of ^{232}Am

D.A. Strellis, K.E. Gregorich, C.A. McGrath, V. Ninov, J.L. Adams, M.R. Lane, C.A. Laue, D.M. Lee, J.A. Patin, D.A. Shaughnessy, P.A. Wilk, D.C. Hoffman

Two experiments were completed at the 88-inch Cyclotron this year to study electron-capture-delayed fission (ECDF) of ^{232}Am using the reaction $^{237}Np(^{4}He,9n)^{232}Am$. We use a He-KCl aerosol jet to transport activity from our Light-ion Multiple (LIM) target chamber[1] to our Sample Changer System (SCS). The SCS uses a rotating wheel to move the sample into a position where a piston can carry the sample to the detection site. We have arranged four Ge gamma/x-ray detectors and two Si particle detectors in a geometry to efficiently detect fissions, alphas, x-rays, and gamma-rays emitted by the sample. ECDF occurs when a precursor nucleus electron captures to a high-lying state in the daughter which then undergoes fission---rather than gamma decay to the daughter ground state. The states that are populated in the daughter are at comparable energies to the height of the fission barrier, thus delayed fission competes with gamma decay. In our ECDF studies of Am precursors, we have detected K x-rays from the EC decay in coincidence with delayed fission events. The fact that there is time for the K-vacancy produced by EC to fill before fission occurs indicates that there is some damping in the second minimum of the double-humped fission barrier of the daughter. Presumably, these delayed fissions proceed through the ground-state of the shape-isomer of the daughters. Thus, ECDF, which proceeds with the EC half-life of the precursor, allows the study of fission shape isomers in an out-of-beam environment.

In our first experiment, we detected about 1600 fission events over a five day experiment. We used these fission events to investigate the nuclear structure of ^{232}Pu, the EC daughter of ^{232}Am. We confirmed the production of ^{232}Am ECDF by detecting the Pu x-rays at 99, 104, and 117 keV in coincidence with fissions. However, we detected only 33% of the expected number of Pu K x-rays in coincidence with fission events. We made some improvements in our calibrations and modified the detector setup in time to run our second experiment of the year. This experiment tested our new setup and studied the ^{232}Am ECDF in further detail. With our improved setup, we were able to increase the efficiencies of the two x-ray detectors by about 50% over the efficiencies measured after the first experiment. This change allowed us to detect more Pu x-rays per delayed fission event during the experiment. We detected over 2300 fissions during this run with 127 +/- 11 Pu K x-rays coincident with fission events. As in the first experiment, the number of x-rays coincident with fission events was lower than expected. This time we saw about 50% of the expected x-ray/fission coincidences. We are currently examining the nuclear structure of the ground state band in ^{232}Pu as well as structure in the fission shape isomer. In addition, we are looking for fission through the shape isomer by looking for gamma transitions in coincidence with both fissions and Pu x-rays.

In our November experiment, we averaged 26 fission events per hours---a 45% increase from the fission rate in our May experiment. We attributed this increase to a modified LIM target system. Instead of collecting the recoils from each of the eleven ^{237}Np targets with one He-KCl aerosol stream as we did in our first experiment, we collected recoils from each target with a separate aerosol stream. This modified design reduces the number of eddy currents within the target chamber, thus increasing the collection efficiency.

Footnotes and References

1. H. L. Hall, et al. Nuc. Inst. Meth. A276 (1989) 649.